DERATING

GENERAL

This document describes the reason that derating can be a desirable tool in the application of electronic parts where unforeseen overstresses may occur. This document also describes some of the theory behind using derating as a reliability tool. Derating is defined as the application of parts in such a manner that the expected stresses are substantially less than the maximum ratings specified. In many cases, the closer that a part is operated to its maximum ratings, the probability of failure will normally be greater.

Derating is a tool that can reduce the probability of failure for a given part, particularly from unforeseen system anomalies and overstresses. Derating is a common practice and can be a valuable tool to achieve the required reliability of a specific application. Optimized part derating is today's preference as it can provide cost benefits by providing increased reliability without burdening the design with costly derating over-kill.

DERATING THEORY

A part's strength varies from manufacturer to manufacturer and even from lot to lot. Part strength is a random process and may be represented by a statistical distribution. Likewise part stress can also be represented by a statistical distribution. Figure 1 illustrates the relationship between the strength of a part and the stress applied at a given time. Each statistical distribution is represented by a probability density function. The average value is the highest point on the curve, and it gradually diminishes at the same rate on either side of the average.

Part strength must exceed part stress in order for a part to operate reliably. However, there is a chance that stress applied to a part will exceed the strength of the part. This is represented by the intersection (shaded area) of the graph in Figure 1. The larger the shaded area, the higher the failure rate becomes. There are two ways in which the shaded area can be decreased. The first is to decrease the stress on a part (which moves the stress distribution to the left). Another is to increase the strength of the part (which moves the strength distribution to the right). In either case, or both, the goal is to decrease the stress-to-strength ratio of the part.

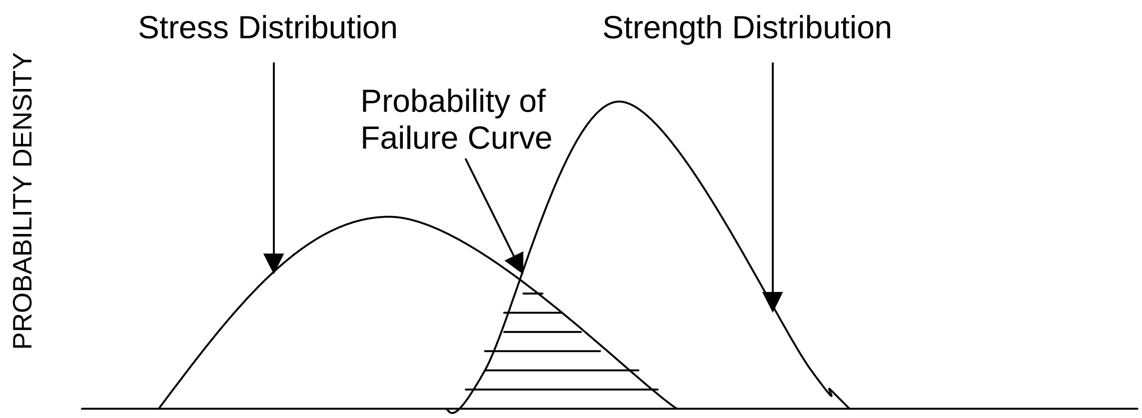

Figure 1. Part Stress vs. Part Strength Relationship

Normally, failure rate increases exponentially with stress. Some failure rates also increase exponentially with temperature. In these cases, by setting temperature and stress limits, failure rates may be decreased exponentially. Ideally, these limits should be set at a point where the rate of increase of failure rate is above an acceptable amount, where the slope becomes too steep. This is the manner in which some derating curves in this manual were derived.

In instances where stress cannot be reduced without a change in the electrical design, a common design approach is to use a higher rated part. The part is then stressed to a lesser percentage of its designed capability. This is analogous to using safety factors in mechanical designs. Usually, the greater the safety factor, the lesser chance of failures due to unexpected overstress.

As a side benefit, derating that also reduces part internal operating temperature can decreases the rate of chemical time/temperature reactions, which are often causes of parameter drifting and device failure.

Different part types are failure sensitive to different types of environmental and electrical stresses. For instance, a capacitor is primarily sensitive to voltage, while a standard silicon diode is sensitive to power, forward current, and reverse breakdown voltage. These are the type of parameters to which derating should be considered.

OPTIMIZING CONSIDERATIONS

There are often circumstances where the full derating requirements in this manual are not cost effective.

Full derating usually requires tradeoffs that are not desirable. For instance, to meet derating requirements, where one part was adequate to perform a function, two parts must be used instead. This increased complexity increases the use of valuable space and adds weight, normally both undesirable traits. However, full derating may not be necessary for systems with short life expectancies, such as missiles and torpedoes, where operating life is only a few seconds or minutes. However, in these circumstances, operational testing or "stand-by" mode operation for long periods of time needs to be addressed. Many system designers derate according to system mission life profiles to achieve an optimum design. This manual was prepared to be tailored to different applications. A statement in the contract stating that the derating requirements may be decreased when appropriate is suggested.

CIRCUIT/PART TOLERANCE

Although derating can increase the life of a part, failure rates vary widely depending upon circuit application and permissible parameter drift. To approach the lowest practical failure rates, designers need to make circuits as tolerant as possible to device parameter variations. Part specifications state the amount of allowable parameter drift, on the average, as a result of artificial aging and environmental exposure; however, individual parts may vary more. Unless the circuit design is sufficiently tolerant, the circuit may not function properly, despite the fact that no catastrophic part failure has occurred.